This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

REESE LIBRARY
OF THE
UNIVERSITY OF CALIFORNIA
OCT 10 1994
Received , 189 .
Accessions No. 54985 Class No.

NATURAL ASPHALT

TWENTY YEARS' PRACTICAL EXPERIENCE

OF

NATURAL ASPHALT

AND

MINERAL BITUMEN

BY

W. H. DELANO

ASSOC. INST. C.E.

GENERAL MANAGER OF THE COMPAGNIE GÉNÉRALE DES ASPHALTES DE FRANCE LIMITED

REESE LIBRARY OF THE UNIVERSITY OF CALIFORNIA.

London:
E. & F. N. SPON, 125 STRAND

New York:
SPON & CHAMBERLAIN, 12 CORTLANDT STREET

1893

TN853
.T7

54985

PREFACE.

IN the year 1880 the author read a paper at the Institution of Civil Engineers, London, on Asphalt, which was reprinted in Van Nostrand's 'Engineering Magazine,' New York, December 1880, and January 1881.

Since that period the use of asphalt (also, unfortunately, of its various imitations) has greatly extended indeed in all parts of the civilized world, so that a popular exposition of its qualities, uses, and abuses, has become a desideratum.

The author has to express his thanks to various directors and managers in London, New York, Berlin, Vienna, Brussels, Rome, Turin, Amsterdam, and above all to the Municipal and Government Engineers of Paris, for much information.

117 QUAI VALMY, PARIS.

CONTENTS.

PART I.

NOMENCLATURE OF ASPHALT AND ITS COMBINATIONS.

	PAGE
Asphalt Rock	2
Asphalt Mastic	3
Gritted Asphalt Mastic	4
Bitumen	4
Butuminous Concrete	0
Geology of Asphalt	6
Analysis of Asphalt	4
List of Asphalt Mines	19

PART II.

USES OF ASPHALT.

Its Qualities	12
Fire- and Vermin-proof Floors	15
Coatings for Arches of Bridges, Viaducts, Etc.	15
Casemates	15
Resistance to Acids	18
Insulation	19
Powder Magazines	19
Vibration-absorbent	19
Roadways	23
Durability	26
Malleability	28
Non-injury by Heat or Frost	29
Noiselessness	30
Agoraphobia: Nervous Affection caused by Street Noise	13
Asphalt Roadways in Paris	32
Wood Pavement	32
Traction on Asphalt Roadways	36

PART III.

MODES OF APPLYING ASPHALT.

	PAGE
ROADWAYS: CAMBER	37
,, SUBSOIL	41
,, CONCRETE	41
,, TIME OF LAYING	43
,, HOT ASPHALT POWDER	43
FOOT-PATHS OF COMPRESSED ASPHALT	45
,, GRITTED ASPHALT MASTIC	45
COATINGS FOR MASONRY	52
CASEMATES	52
ROOFS	52
SILOES	53
VERTICAL APPLICATIONS	53
INSULATION OF ELECTIC WIRES	55
ASPHALT FLAGS AND SLABS	57

PART IV.

GENERAL OBSERVATIONS.

WIDTH OF TIRES FOR HEAVY TRAFFIC	58
USE OF SALT FOR MELTING SNOW	58
KERBS	59
SPEED OF STREET-TRAFFIC	59
TRAMCAR RAILS	60
MAINTENANCE CONTRACTS	60
CONVERSION OF OLD ROADS INTO ASPHALT ROADS	60
CAUTION MONEY AND MODE OF PAYMENT	61
MAINTENANCE	62
LOW PRICES	65
IMITATIONS OF NATURAL ASPHALT	66
TRAFFIC OF PARIS	69
WEAR OF MACADAMISED ROADS	70
WORK DONE BY PARISHES WITHOUT CONTRACTORS	71
COST OF WORK IN PARIS	72

REESE LIBRARY OF THE UNIVERSITY OF CALIFORNIA

TWENTY YEARS' PRACTICAL EXPERIENCE

OF

NATURAL ASPHALT

AND MINERAL BITUMEN.

PART I.

NOMENCLATURE OF ASPHALT AND ITS COMBINATIONS.

FOR all that concerns the origin of asphalt, its nature, history and geological formation, and mode of extraction, the well-known work* of M. Léon Malo (who for thirty years has been the prophet of natural asphalt) is the best guide. Of this gentleman the author is an earnest and grateful disciple.

Nomenclature.—Asphalt is a natural product (see Fig. 1), a bituminous limestone in which carbonate of lime and pure mineral bitumen are most intimately combined by natural agency, the proportions varying from 7 per cent. bitumen and

* 'L'Asphalte: son origine, sa préparation, ses applications, par Léon Malo.' Baudry & Cie., Éditeurs, 15 Rue des Saints Pères, Paris.

Fig. 1.—NATURAL ASPHALT ROCK.

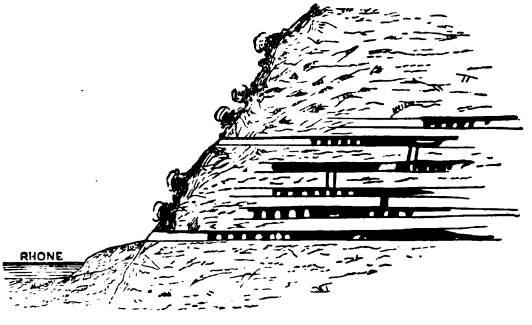


Fig. 2.—SECTION OF AN ASPHALT MINE.

93 per cent. carbonate of lime to 20 per cent. bitumen and 80 per cent. carbonate of lime.

It is found in seams like coal, and mined in the same way (see Fig. 2). Heated on a hot plate it falls to pieces (see Figs. 3, 4).

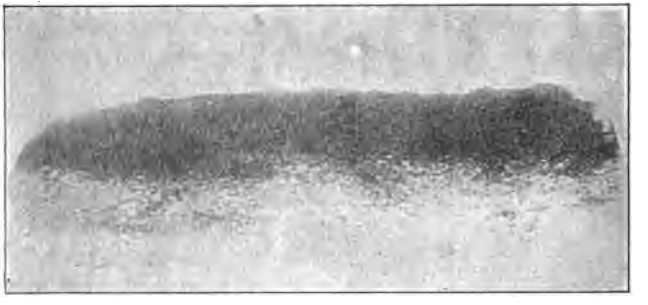


Fig. 3.—ASPHALT ROCK COMMINUTED BY HEATING ON AN IRON PLATE—SIFTED.

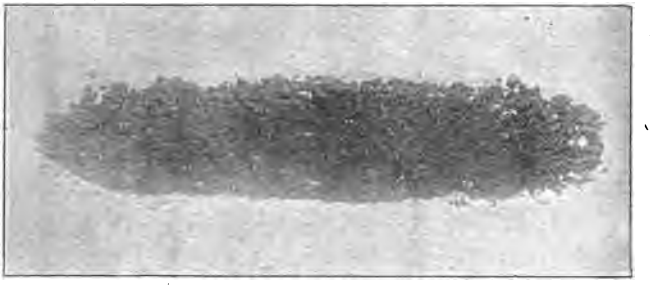


Fig. 4.—ASPHALT ROCK COMMINUTED BY HEATING ON AN IRON PLATE—UNSIFTED.

Asphalt Mastic, when pure, is composed of asphalt rock ground to a fine powder and mixed hot with

a varying proportion of hot bitumen similar to that contained in the natural rock, the pasty product being run into moulds, forming the well-known cakes, which weigh about 56 lbs. Their diameter is 30¼ inches, and they are from 4 to 4¾ inches high. Analysis should show about 15 per cent. bitumen and 85 per cent. of limestone in these cakes.

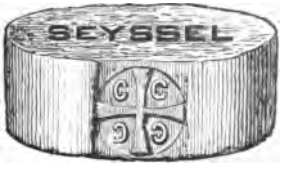


Fig. 5.

Gritted Asphalt Mastic is composed of pure asphalt mastic, broken to small pieces of from ½ to 1 inch in diameter, remelted in a kettle (see p. 50). There is added 5 per cent. of pure bitumen and from 30 to 40 per cent. of fine clean dry grit, the grains of the latter above ⅞ inch in diameter.

The author prefers limestone grit, but if silicious grit only can be obtained it should be as fine as sea sand.

Asphaltic or Bituminous Concrete is composed of two parts of hot gritted mastic mixed with three parts of flint pebbles, or rubble, about 2½ inches diameter. The stones should also be hot.

Bitumen is a mineral product found in asphalt rock, whence it can be extracted pure. It is found in the Trinidad "Pitch Lake," mixed with 33 per cent. of fine clay sand and vegetable matter, and 33 per cent. of water. It is also found in various

states of purity, sometimes mixed with sand or sulphur, in Auvergne (France), Chieti (Italy), Avlona, Selenitza (Albania), Beyrout, Venezuela, California, Kentucky, Utah, and elsewhere, particularly the Dead Sea (see p. 11).

Bitumen is an exact synonym of mineral pitch; it is in fact the Latin equivalent for pitch, and the adjectival form "bituminous" has replaced the Saxon form "pitchy."

Bitumen is allied to petroleum, naphtha and shale oils; but it is not by any means identical, as the results of their use show. It is, as M. Malo writes, only "similar to itself."

The type and standard of mineral bitumen is that extracted from Seyssel asphalt, which can be subjected to 500° Fahr., or $x°$ below freezing point, without losing its tenacity, malleability, or suffering any deterioration.

Its composition is:—

Carbon	85 parts.
Hydrogen	12 ,,
Oxygen	3 ,,
	100 parts.

Bitumen is therefore the principal ingredient of asphalt, but in that latter body is so intimately intermixed with the limestone by Nature itself that the result—asphalt—must be considered an independent material, like granite or porphyry, Roman cement or coal.

It may be imperfectly imitated, created it can

never be. Bitumen, it would seem from the testimony of the Seyssel asphalt mines, may have

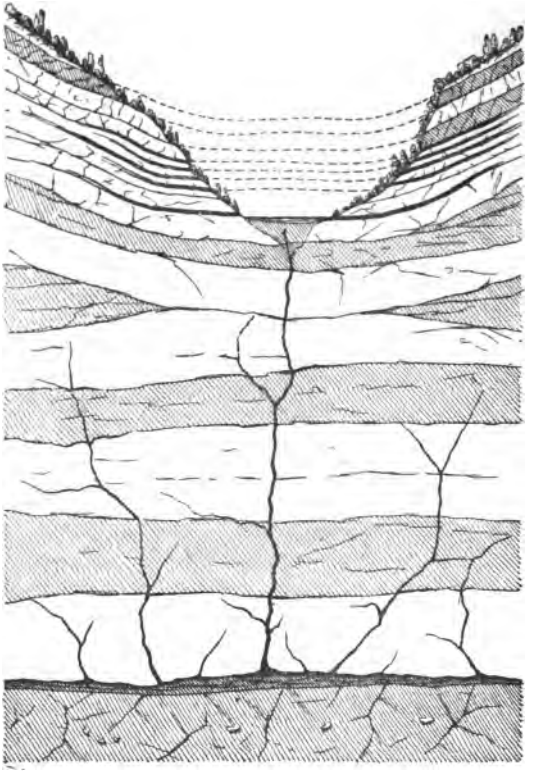


Fig. 6.—PROBABLE FORMATION OF ASPHALT. AFTER RIVER-EROSION.

permeated, whilst in a state of vapour, the limestone, which at that period must have been soft (see

hypothesis below). Only the perfervent heat of Nature can have vaporised carbon.

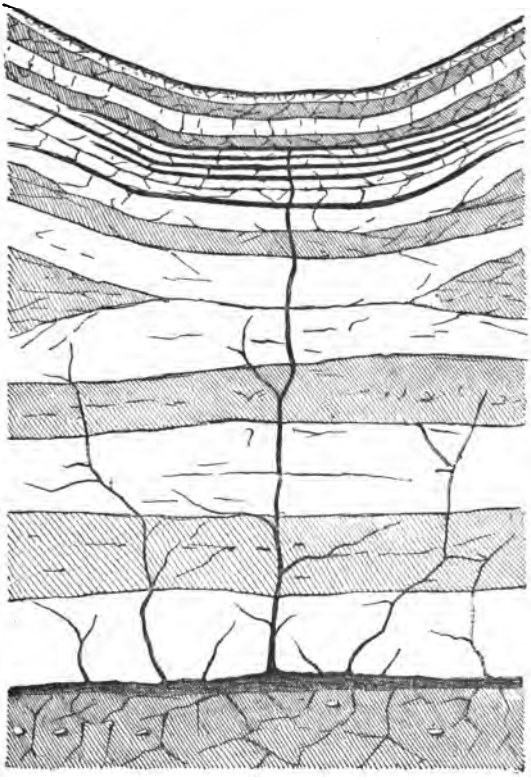


Fig. 7.—PROBABLE FORMATION OF ASPHALT. BEFORE RIVER-EROSION.

Asphalt is generally found in 6 to 10-feet seams, between two layers of white hard limestone, either

totally unimpregnated with bitumen or else with mere traces of it, which have the appearance of thin smoke or the faint stains in white marble. Sometimes, however, layers of sand and marl are found, which must be propped, or held up by rubble.

Some contractors (outside Europe) have quite recently used the term asphalt and bitumen as though they were synonymous and interchangeable, and even such an anomalous phrase as the following has been seen in print:—"Asphalt from the Trinidad Pitch Lake." Such misuse of terms should be strictly avoided in estimates and specifications, as causing confusion.

Bitumen and mineral pitch are interchangeable terms, but asphalt stands alone.

The necessity for a clear and precise nomenclature is shown by the interesting 'Report on the Geology of Trinidad,' by G. P. Wall and J. G. Sawkins, F.G.S.,* where the words—

Asphaltum, Asphalt, Bitumen, and Pitch	are used to express one and the same article, viz. Trinidad Pitch.

There seems some tendency in the best human nature to abuse synonyms and revel in tautology.

Sometimes from bad habit, sometimes from fraudulent motives, gas-tar, Stockholm tar, petroleum and naphtha residuum, shale grease, hard

* Longmans, London.

pitch from the distillation of animal fat, are called asphalt. This misappropriation of terms, this "calling evil good," should be sternly reprobated by engineers, architects and chemists who cherish clearness of expression and detest puzzledom.

Analysis of Asphalt (Natural product).—As mined, the rock should be of a chocolate colour, fine in grain, evenly impregnated with bitumen, free from sulphur, pyrites, clay, sand or other extraneous matter. When examining with the microscope, always look at a fresh fracture.

Rich Val de Travers rock, containing say 11 to 13 per cent. bitumen, should be mixed with one-half of fine Seyssel rock containing 7 per cent. of bitumen, which is fixed and invariable, producing thus $\frac{11\% + 7\%}{2} = 9$ per cent. powder, suitable for a climate like that of London.

The same may be done with Ragusa (Sicilian rock), which is rich in bitumen of excellent quality, only the texture or grain of the limestone is loose, whereas that of Seyssel is fine and dense.

Mons and St. Jean de Marvejols asphalts are similar in structure to Ragusa, but the limestone is much finer.

The rough and ready way of testing asphalt is to dissolve its powder taken from a three-ton bulk, in carbon bisulphide, turpentine, or ether. Stir well with a glass rod and strain through a thick paper filter; then let the sulphide evaporate,

REESE LIBRARY OF THE UNIVERSITY OF CALIFORNIA.

which it will do at 70°; weigh the bitumen and the residuum, afterwards washing the latter in hydrochloric acid, which will cause the lime to effervesce, leaving any silica, pyrites, &c.; but for an absolute test an analyst accustomed to hydrocarbons should be called in.

The same test does for bitumen, to ascertain the proportion of clay or other impurities in it; naturally the practical test for a new asphalt is to lay it in a crowded thoroughfare and let three winters and summers pass over it.

Refined Trinidad Pitch will always contain from 20 to 25 per cent. of fine clay; nevertheless it is so tough, malleable and stringy, that for asphalt mastic it is preferable to some other short fibred bitumens chemically purer.

List of Asphalt Mines.—Asphalt is found near Seyssel, France, in the Rhone Valley between the towns of Bellegarde and Seyssel, the centre of the concession being the railway station of Pyrimont, specially created for the important mastic works of the Compagnie Générale des Asphaltes de France, of 117 Quai de Valmy, Paris; at Travers, belonging to the canton of Neufchâtel, Switzerland, conceded till 1907 to an English company in London; Mons and St. Jean de Marvejols, near Alais, France; Chieti, in the Abruzzi, Italy; Ragusa, Sicily; Auvergne (though here mostly bituminous sandstone); Lobsann in Alsace (much

mixed with iron pyrites); Limmer, near Hanover, Germany. Sandstone impregnated with bitumen is found in Kentucky, Utah, California, and at Maestu in Spain.

The chief source of supply of mineral bitumen is the British island of Trinidad, West Indies, but there are also supplies to be had from Chieti, Italy; Auvergne, Vallona, Albania; Bermudez in Venezuela; Barraquilla in Columbia, Central America; Province of Oran, Algeria; * Beyrout, Syria, &c. The bitumen from the Dead Sea is only used for medium or black varnish; the supply is scanty.

Bitumen to be good should be free from dross, non-evaporative and contain no oils that will evaporate at 480° Fahr.; be perfectly black, not brilliant, and at 70° Fahr. have the consistency of bees'-wax. The best way to test the quality is to draw it out in threads; the longer they stretch the better the sample.

* The author saw, some ten years ago, in Algeria, an Arab sheikh, on the borders of the Chelif River, who was pitching his shallow flat-bottomed boat with pitch from a scanty bituminous spring near, and was reminded of the divine command to the Patriarch Noah—"Bituminabis eam bitumine" says the Vulgate.

PART II.

THE USES OF ASPHALT.

BEFORE describing, from long and varied experience, the best modes of using asphalt, the author would express his firm belief that this valuable and unique material was specially created for certain ends, like coal, iron, copper, &c. It is for man to study and utilise the gift.

Its Qualities.—After the necessary manipulation, it becomes impervious to water and air, resists fire and acids, insulates the electric circuit, produces no sparks by contact with iron, repels vermin, absorbs vibration ; its vapours are antiseptic ; it is durable, easily repaired ; so malleable that it can be applied to any curve, so ductile that it will yield to any ordinary pressure from whatever direction without cracking. It is unaffected by frost, and though slightly softened by heat, say 125° Fahr., it never disintegrates, even at 450°, and upon returning to its normal temperature has lost none of its qualities.

It produces no dust, consequently no mud.

It can be laid by workmen of ordinary intelligence in any climate, for its malleability can be

increased or decreased at will, so as to suit the temperature of arctic or of tropical regions.

Apart from its hygienic properties, its noiselessness, its harmonious tint, it is most agreeable to walk upon (not hard and slippery, like granite, cement, tiles, &c.). It is in fact the street carpet.

Its duration is greater than that of granite and flag, its first cost and annual maintenance less.

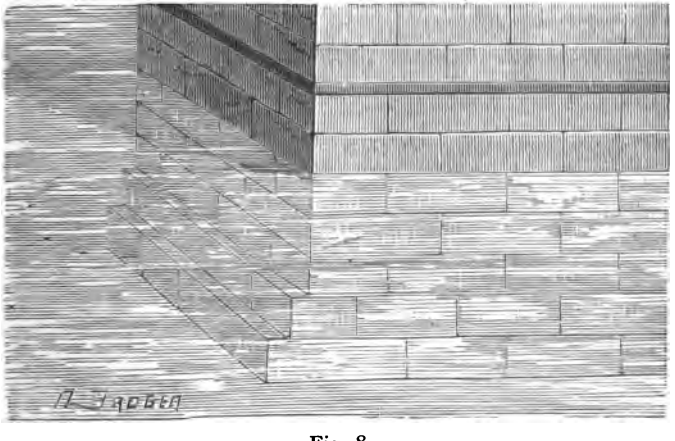


Fig. 8.

The traction for horses on the level is easy, they can draw from three to six times as much as on rough coarse metal or stone pitched roads.

Imperviousness to Moisture.—Let us consider the "damp course" (Fig. 8), so simple, and so useful, that it ought to be made compulsory in building operations.

When it is remembered that one porous brick, $8\frac{1}{2}$ inches by $4\frac{1}{8}$ inches by $1\frac{1}{4}$ inches, weighing say 4·78 lbs. avoirdupois, will absorb and hold $\frac{3}{4}$ lb. of water, one is astounded at the amount of water there may be contained in an ordinary wall, drawn up by capillarity, causing rheumatism, fever, and other diseases, apart from discomfort and depression, shortening the lives of adults, checking the

Fig. 9.

development of children. Asphalt arrests capillarity, and settlement of masonry does not cause it to crack like cement.

Some twenty-five years ago, a handsome house was built on the borders of the Lake of Enghien, a Seyssel asphalt damp course was used, and the walls, as far as regards the unceasing action of capillarity, kept perfectly dry. But one day some

underpinning was done; the mason forgot to relay the asphalt damp course, or else thought it was a fad and wilfully neglected to repair it; the consequence was, walls saturated to such an extent, that the house became uninhabitable.

Fire- and Vermin-proof Floors.—An excellent and springy floor is made by setting the joists in asphalt mastic, and afterwards nailing down the battens in various patterns, care being taken not to leave sufficient space between the battens and asphalt for rats and mice to pass; the asphalt is uninflammable, and will not allow air to pass (Fig. 9).

Sometimes the boards or battens are laid direct on asphalt without joists, but then the floor is not so elastic, and may not always keep level.

Coatings of Asphalt Mastic upon the Arches of Viaducts and Bridges of Stone or Iron keep out moisture from above, and so prevent the action of percolation and frost upon the joints and keystones, and thus arrest decay. (Figs. 10 and 11.)

Water is the enemy and must be kept out—well laid asphalt is the remedy. How many accidents are constantly occurring to railway bridges, owing to the neglect of so simple a precaution.

Casemates should always be coated with liquid asphalt under the bomb-proof earth covering (see Fig. 12).

In time of war soldiers must live in dry casemates or they will soon be down on the sick-list.

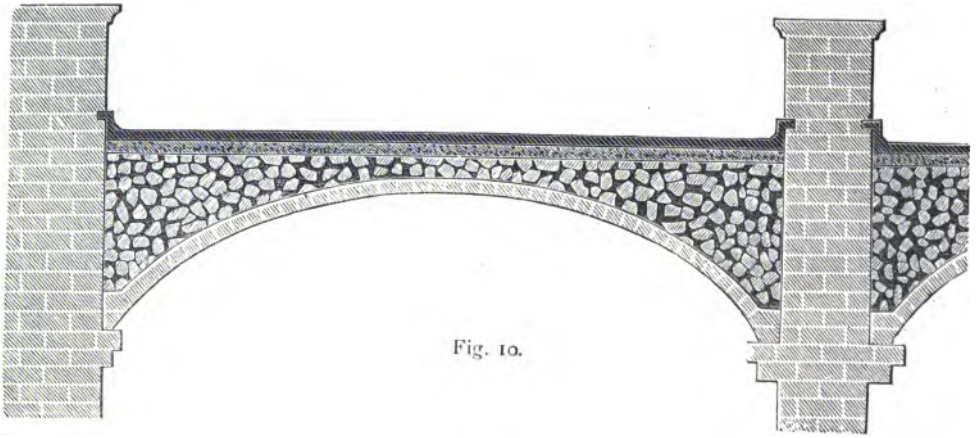


Fig. 10.

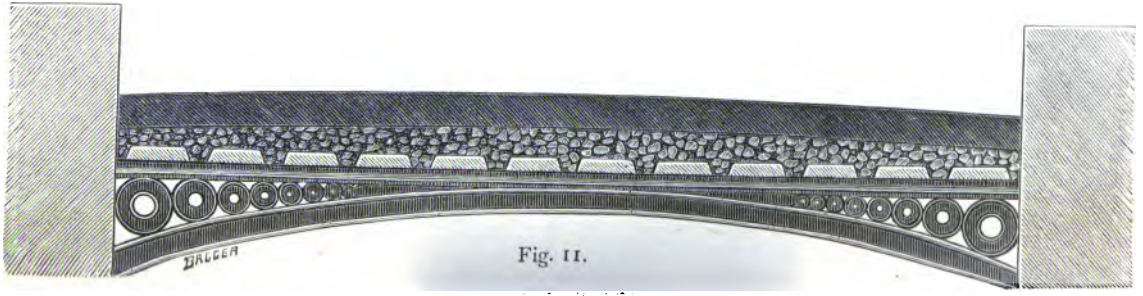


Fig. 11.

Military engineers are expensive, and it pays to take care of them.

Heavy masonry always settles, and if only a Portland cement coating be used it will crack and split, and be of no more use to keep water off than a sieve.

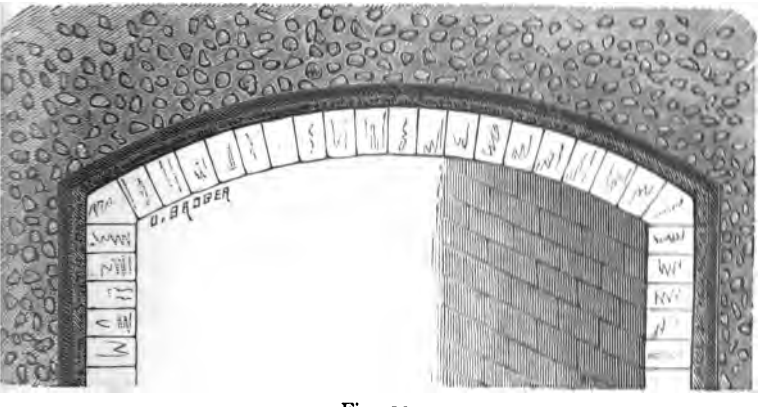


Fig. 12.

The author once witnessed the following proof of the correctness of this. About 20 feet of earth was removed from the roof of a bomb-proof casemate, and the coating of Seyssel asphalt examined, after 40 years' burial. There was no crack anywhere, it had yielded to the settlement of the masonry, long roots of lucerne had in vain tried to penetrate it. The interior of the casemate was dry and habitable.

The strong room of an important Public Company in Paris has been walled with bitu-

minous concrete, the walls, with books inside, having been previously submitted to a fierce fire. It is as impenetrable to air as to water.

When a coating of gritted asphalt is used on a roof, it will, in case the foundations are burnt, fall in and stifle the flames like a wet blanket.

The result has been proved by insurance companies on several occasions,* by actual tests.—It is flame-proof.

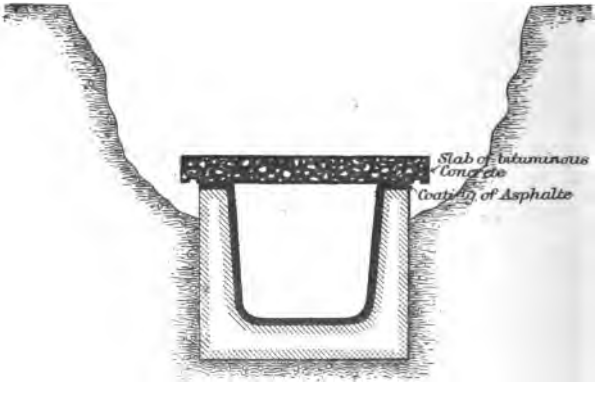


Fig. 13.—CONDUIT FOR ELECTRIC WIRES.

Resistance to Acids.—Specially-made mastic will resist the action of acids for a long time; the bitumen resists completely and defends the lime-

* See 'Note sur l'application de l'asphalte coulé sur les planchers des Magasins et Greniers pour empêcher la propagation de l'incendie. Imprimerie E. Capiomont et Cie, 6 Rue des Poitevins, Paris, 1888.'

stone component. It is used for lining tanks required in electrolysis and for electric batteries.

Insulation.—Bitumen is an excellent insulator for electric wires, at least 30 per cent. superior to gas-tar. It will resist the action of underground moisture.

The author has often seen leakages of electricity completely arrested by drowning the wires in asphalt mastic as they lay. This was particularly the case at the National Opera House in Paris, where condensed water, getting into the trough where the wires were, rotted the hempen coating and caused a leakage of 30 per cent.

Powder Magazines.—Asphalt produces no sparks by contact with steel, so is excellent for powder magazines. The floors, often made with timber fastened with copper nails, rot after a time, but asphalt defies time. Of course, for powder magazines pure compressed or pure liquid mastic should be used, *not* gritted mastic.

Absorption of Vibration by Bituminous or Asphaltic Concrete and Compressed Asphalt Powder in Moulds.—One of the most interesting applications of asphalt is that of bituminous or asphaltic concrete for quick-speeded machinery, such as dynamos and their motors, grinding machinery like Carr's disintegrator (700 revolutions per minute)

hydro-extractors (1400 revolutions per minute), printing-machines, and percussive machines like gas-engines, stamping-presses, steam-hammers, spring-hammers, &c.

The author has during the last twenty years arrested many a lawsuit begun by indignant neighbours against users of machinery in the crowded houses of cities. A high-speed engine working in a cellar will make a seven-story house tremble, and at night prevent sleep of the inmates.

The asphalt concrete may be run in moulds to any shape and sold by the cube.

The cure is complete, when the mass is big enough. For instance, take the foundations for a stamping-press, the gradual annihilation of the concussion can be felt by placing the hand on the side of the block of bituminous concrete which receives it. The latest application of asphalt concrete for this purpose is that of the electric-light motors at Moët and Chandon's, Épernay, France, where it was absolutely necessary to prevent the 8,000,000 bottles of champagne in the cellars from shaking.

The foundations for the dynamos and their motors in most of the Paris theatres are of bituminous concrete. They are surrounded by brick walls. No vibration is felt; the temperature in the cellars where the engines are is 120° Fahr.

For steam-engines the surface of the foundation must be laid in cement, or have a layer of stone, to avoid bad effects of oil and grease, which are pre-

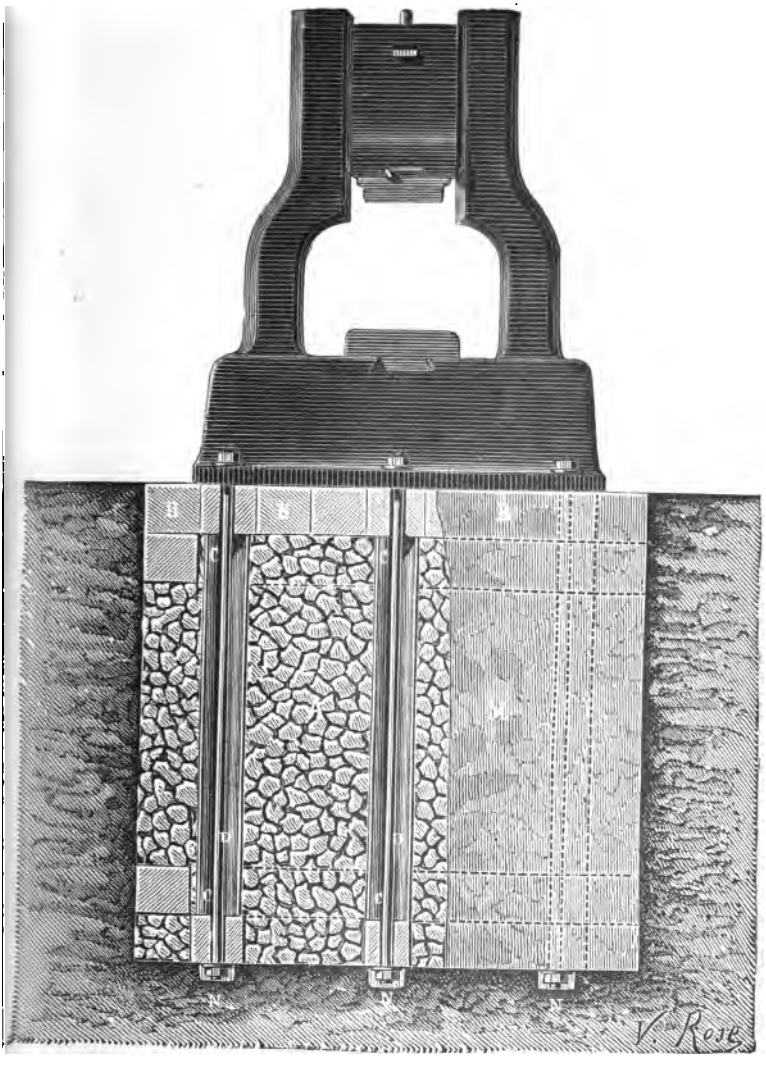


Fig. 14.

judicial to asphalt after a certain time. This application of asphalt requires extra care, and must not be attempted except by professional asphalters, as a failure would be no trifling matter. Only the best materials must be used. A block may take three days or more to settle and cool.

The same effect can be obtained by successive layers of hot asphalt powder compressed in a strong steel frame ; and this plan is used for steam hammers, avoiding the jarring of walls and the breakage of glass in skylights, &c.

M. Malo was the first to use asphalt to avoid the vibration of machinery, and has carried out at Pyrimont Works, the centre of the Seyssel Asphalt Concession, many ingenious applications. The author has followed his lead in Paris. The instances are now too numerous to detail ; they vary from stamping-presses and printing-machines to the heaviest engines.

At the present time (1893) an underground railway is being constructed near the astronomical observatory of Paris. The astronomers find that their mercury bath and various delicate instruments vibrate. Both M. Malo and the author are being consulted as to the remedy, which will have to be paid for by the railway company.

Either the instruments will have to be mounted on bituminous concrete foundations, or else the whole building of the observatory be insulated by a wall of bituminous concrete at considerable expense.

Many useful new applications of asphalt concrete

are yet in their infancy. One is to line the granite embrasures of forts with this material, which makes no splinters. Splinters often do more harm to artillerymen than explosive bullets. Leaden bullets will flatten when fired against asphalt powder heaped up.

It is this quality, shared by indiarubber, cork, and to a certain extent wood, which, coupled with its impermeability and artistic colour, renders compressed asphalt so suitable for the streets of crowded cities.

The din and jar of street traffic are a torment to artists, literary men, men of business, women and young children.

The passing at 8 miles an hour of a heavily laden four-wheel van over a stone or cobble roadway, will make a six-story house tremble from top to bottom, and often dislodges bricks, tiles, and architectural ornaments.

It is fortunate for dwellers in cities that there exists in compressed asphalt a pavement, cheaper than granite, that suppresses such exasperating annoyance.

Asphalt roadways enhance the value of house property, diminish traction, are not of themselves slippery; produce no dust, therefore no mud; absorb no liquid nor solid excremental matter, nor filth nor putridity, therefore under the hot blaze of a summer sun emit no miasmata. Asphalt affords no element for fermentation, is therefore *hygienic* par excellence.

It should be used universally; the only excuse admissible for its non-use should be the want of money and the power to borrow it. But there are always enemies to progress—those who say, What was good enough in old times is good enough now; those who ignore the results of comparative experiment; the faddists; and those who condemn without examination.

Now what are the *disadvantages* of asphalt? The wise man who has to judge a new material or process may make two columns on a sheet of paper, inscribe in the one the advantages, in the other the disadvantages; the balance is one side or the other—then he knows what course to pursue.

Now a smooth pavement is unsuitable to horses with a load to drag. There is no grip, and it may be laid down that, in almost all circumstances, 3 in 100 is the maximum gradient for compressed asphalt roads.

Again, in the temperate zone there will be some days in the year when it drizzles. Then the fine dust lying on the asphalt is at once converted into a thin pellicle of sticky mud, which may cause horses to slip unless well held up by their drivers; a heavy rain does no harm, indeed it does good by washing the surface.

In Paris, where compressed asphalt was first used, there are bins in the foot-paths or side-walks containing stores of fine red sand.

The scavengers at once sprinkle the asphalt surface; the men use a wheelbarrow and

shovel, giving the latter a smart twist at the moment of throwing, which scatters the sand uniformly, and slipping is prevented; but the better plan, which is also used in Paris, is to screw the hose on to the street hydrant and flush the surface, afterwards using the squeegee.

When a horse falls on asphalt he does not break his knees as he would on stone setts or macadam.

Some sand, ashes or cinders thrown will facilitate his rising, or a cloth thrown under his fore legs.

Horses get accustomed to asphalt, and must like it, at any rate 340 days out of the 365, as the traction is so much easier than on stone, macadam, or wood.

It is quite clear that when improved roadways are made, there must be provided also improved modes of cleansing them.

Compressed asphalt must be kept clean from horse-dung and other impurities, and be flushed once at least in 24 hours, either by hose and hydrant or by water cart, and then squeegeed.

In big towns there should always be a complete organization for street-cleaning; dust, mud, and filth must be removed for the health and comfort of all citizens, tax-payers or not.

Dry east winds do not only arrest the action of the liver, but the parched state of the roads allows of poisonous dust being conveyed to the respiratory organs. "Wash and be clean" applies to streets as well as to human bodies.

REESE LIBRARY OF THE UNIVERSITY OF CALIFORNIA

The author, who has lived most of his life on the continent of Europe, was, in a recent visit to London, walking up from Victoria Station to Westminster Abbey by Victoria Street. During this short walk, at four points miserable crossing-sweepers importuned him for making a passage across a coating of slimy mud, which in Paris would have been cleared away before 8 a.m.; but when wishing to cross the same roadway from the Abbey to Great George Street, there was such a sea of slush on the spongy wood pavement that he was compelled to carry his twelve-year old daughter across as though it were a river ford.

Later on the author saw a house in Trafalgar Square, the walls of which were literally black as soot, and was informed that it was the College of Physicians. Dear old London! the richest, and, after New York and Chicago, the dirtiest city in the civilized world. When will it be kept like Paris?

Yet there are able-bodied paupers of both sexes in the workhouse, doing nothing for their board and lodging, who would make excellent sweepers. Local Boards must learn to vote money for street cleaning.

Durability.—Compressed asphalt, subjected to ordinary wear and tear, will last without complete renewal from 15 to 30 years; for instance, the compressed asphalt laid in Cheapside in 1870, resisted the central traffic of London for over 17 years, without causing a single day's stoppage of

traffic; and there are streets in Paris where the asphalt is over 30 years old.

Fig. 15.—COMPRESSED ASPHALT FROM PARIS ROADWAYS.

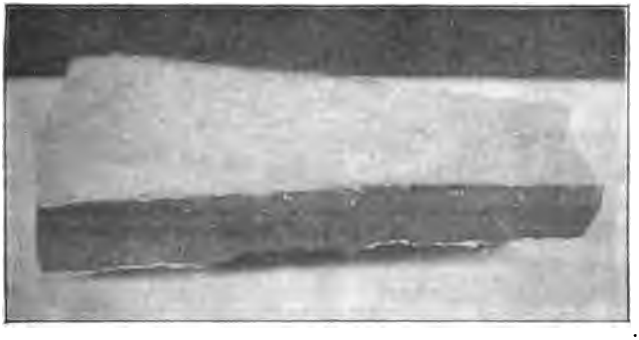


Fig. 16.—COMPRESSED ASPHALT FROM PARIS ROADS, REDUCED BY WEAR FROM 2 INCHES TO $\frac{9}{16}$THS INCH.

The life of an asphalt roadway depends upon the number of vehicles passing in 24 hours, their

weight and speed, the use of brakes; also upon the amount of rainfall, of frost, of hot sun.

Repairs are made in dry weather with hot powder, and a careful workman will not let his jointing be visible.

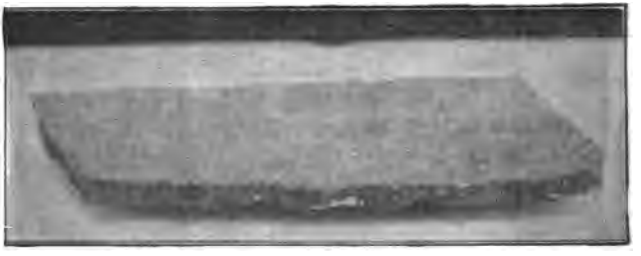


Fig. 17.—COMPRESSED ASPHALT FROM PARIS ROADWAYS, REDUCED BY WEAR FROM 2 INCHES TO $\frac{5}{16}$THS INCH.

In persistently cold, wet, foggy weather, holes can be temporarily stopped by liquid asphalt in two layers, but a dry surface of concrete can be obtained by spreading a thin layer of liquid mastic over it.

Malleability.—Asphalt, particularly in its form of mastic, is slightly elastic, and at ordinary temperatures (say 60° Fahr.) ductile.

This gives it the advantage over cement coatings, which are non-elastic, and therefore crack and crumble. Cement once used is lost, whereas asphalt mastic, like lead, can be used over and over again by adding new refined bitumen.

In Paris, where there are many trees in the public thoroughfares, the roots often force up the footpaths or side-walks, yet the asphalt mastic rarely cracks, although it contains a large proportion of grit; it bulges up only. In a pure state, and without grit, it might be folded double without cracking.

Not affected by Frost.—This quality allows of snow being removed from it with ease, and there ensues no perceptible contraction or expansion, however sudden the changes of temperature may be. In this respect it compares favourably with wood pavement, which swells up after rain, or frost following rain, the force of which expansion is resistless, pushing up kerbs, overturning street lamps, or in case of the over-resistance of a party wall buckling up on itself.

Not affected by Heat.—Its nature is not altered thereby; it softens slightly under extreme day heat (say 100° Fahr.), but returns to its original form at sundown. It is a non-conductor.

Vermin.—It repels rats and mice, perhaps by its smell, but chiefly by clogging up their teeth: thus in Paris, where there are as many rats as Parisians, the sidewalks are undermined, but the gritted asphalt mastic is never gnawed through, yet cement is attacked.

This quality renders asphalt excellent for

stables, granaries, stores, warehouses, corn-mills, breweries, malting-floors, distilleries, dairies, cheese factories, &c.

Perfection is not of this World.—Asphalt has, as the French say, "the defects of its qualities," as being impervious to water; condensed atmospheric water remains upon it instead of being absorbed. The only remedy for this inconvenience is a coarse sponge, or an oakum swab. Asphalt does not hide damp, it discovers the enemy which, being seen, can be grappled with.

The best tool for removing moisture from a horizontal asphalted surface is the invaluable squeegee.

It is also well to remember that asphalt, like indiarubber, has no great powers of resistance *per se*, but is strong when supported by solid foundations or defended outside by vertical masonry.

Noiselessness.—It is of course owing to the presence of mineral bitumen in the limestone which causes percussion and vibration to be absorbed; also to this peculiar fact, that in a compressed asphalt the roadway is always of closer texture than the underlying parts. This is just as perceptible in asphalt worn to less than half its original thickness. (See Figs. 15 and 16 *ante*.)

The sound of the horses' hoofs is heard as a sharp "toc-toc," without vibration or resonance, warning the pedestrian of an approaching vehicle, while the rolling of the wheels is noiseless, for the

wheels do not bump on asphalt as they do on stone or macadam.

On wood pavements the sound of the horses' hoof is not heard—a danger for deaf or careless crossers.

It has been said indeed, that wood pavement cures deafness by killing off the deaf.

Agoraphobia.—In these modern times a new malady has arisen. Agoraphobia is the mental suffering caused by street noises of all kinds, but particularly the rumbling of heavy vehicles on granite setts or cobble pavements.

In Paris, for the last twenty-five years, landlords, managers and heads of schools, churches, theatres, banks, as well as private householders, have clamoured for compressed asphalt roadways, in some cases, where the stone road was new, paying *2s. 6d.*, or say 60 cents, per foot run for the substitution.

Since the cholera scare (1892), a large number of narrow streets and blind alleys, and small yards have been asphalted for hygienic reasons.

The imitation of natural asphalt will be treated further on.

It is an old adage that "imitators always fall short," and when the difference in price is so slight between the two articles, it is not worth while to encourage the imitation.

The only excuse for using imitations is their low first cost, and that is false reasoning, for the

increased cost of repair is infinitely greater than would have been the interest on the additional outlay for the real article, besides which, the complete break-up which always ensues, involves the cost of relaying, after all the annoyance to the neighbouring householders and shopkeepers caused by the repairs.

Asphalt Fiasco in Paris.—In 1878, the City of Paris let its tried contractor go, tempted by the low prices of a reckless bidder, with the result than in 1883, Paris asphalted streets had gone to the dogs, and had to be relaid in 1884, at a cost of 6,000,000 francs (240,000*l.*) or 1,200,000 dollars.

The contractor, who had deceived himself as well as the town, died in a mad-house, leaving a host of creditors with zero for assets, who blamed the town authorities for being the indirect cause of their losing their money, they believing that a municipality only employed solvent and honourable contractors.

Wood Pavement.—About the year 1840 wood was used for roadways, found wanting and abandoned ; but since about ten years ago, owing principally to the failure of bad asphalt in Paris alluded to above, it has been largely used. When laid upon a Portland cement concrete bed, it is certainly a great improvement upon macadam, indeed, when first laid it is admirable ; but it is not a hygienic pavement, because it is porous. As animals have not

yet been trained to use water-closets and urinals the public highways are defiled with their dung

Fig. 18.—WOOD PAVEMENT CUT FROM PARIS STREETS.

and their urine; these, as well as other filth, are absorbed by the wood, and ferment in its fibres.

Under a hot sun, morbid germs are drawn up into the atmosphere and inhaled by the inhabitants, stunting the growth of children and debilitating adults.

The surface of wood pavement becomes, after one, two, or three years, according to traffic, like a

Fig. 19.—PULVERIZED WOOD FIBRE MIXED WITH HORSE-DUNG AND OTHER IMPURITIES, FROM WOOD PAVEMENT.

worn-out tooth-brush (see Fig. 18, representing a block taken from a Paris street after one year's wear).

The fibres from this disintegrated surface, mixed with horse-dung and filth, are pounded and ground up by the traffic (see Fig. 19), and in this form, on a dry day, are swallowed by the citizens, or carried home in their hair and garments.

Since the introduction of wood pavement in London and Paris, oculists have found inflammation of the white of the eye (conjunctivitis) greatly on the increase. Such a fact is not astonishing, as dust from decayed wood pavement is poisonous.

Wood pavement, to last, should be kept always wet, but wet wood has a most lugubrious appearance.

In winter, when the frost gets into it, the surface becomes glazed to such an extent that horses cannot move on it without slipping ; it is dangerous.

An eminent English engineer once said of wood pavement ; first year excellent, second year good, third year bad, fourth year very bad, fifth year take it away. As before said, when laid on concrete with a certain slope, wood has its advantages, the joints give a foot-hold to the horses on an incline, and the water can get away, but on the flat, the rain water which percolates down to the concrete, but cannot penetrate it, rots the wood at its base.

In New York, Berlin, and the City of London, wood is no longer used, but it is employed in the London suburbs and in Paris, in which latter streets, the municipal authorities lay it themselves without the intervention of a contractor, as do also certain London parishes.

Dr. J. B. Fonssagrives in his excellent and most interesting work 'Hygiène et Assainissement des Villes'* says (p. 19), " Hygiene cannot approve of the covering of a road by a porous substance, apt to become impregnated by organic matter, and supplying by its own decomposition miasmata, which, let loose from such an extended surface, cannot be disregarded. *I am convinced that in a*

* Paris, J. B. Baillière et fils, Rue Hautefeuille.

damp town entirely paved with wood, marsh fever would become endemic."

There is another danger, viz. that in case of riots the wood blocks smeared with petroleum and set alight, might aid the criminal design of incendiaries, as in the case of the Paris Commune in 1871.

Traction on Compressed Asphalt Roads.—Many dynamometrical experiments have been made to arrive at the coefficient of traction for each kind of road, and have yet to be scientifically carried out.

Evidently, such experiments should be made with vehicles of the same weight and diameter of wheels, same width of tire, on same level, with same conditions of temperature and dryness, same speed, horses shod the same without calkins or toe-pieces; but it may be taken roughly that the traction on asphalt, say at 75° Fahr., being 1, that of stone setts will be 2, of rough granite and ordinary macadam 3, on rough macadam 5 to 6.

PART III.

MODE OF SETTING OUT COMPRESSED ASPHALT ROADS.

THE first thing to be considered is the camber, which is pitched much lower than for wood, stone, or macadam, because the asphalt surface being smooth, as well as impervious, the water runs away to the gutters more easily.

After trials of many cambers during the last twenty years, the author concurs generally with the following formula, drawn up by the late M. Saint-Ange Allard, Chief Engineer of the City of Paris. The figures are millimetres, and are thus given because the metrical system is now so much used.

$$R = 0{\cdot}012 \text{ metre } \frac{W^2}{W^{-1}}.$$

R = rise of camber, the perpendicular at highest point.
W = width of roadway.

Thus, supposing a roadway to be 12 metres or 13 yards wide from kerb to kerb, the rise would be 0·157 metre at the centre or crown, or $6\frac{3}{16}$ inches, but as we take off 1 metre or 3 feet 3 inches from

the kerb to form the gutter—measuring from that last limit, the rise is nearly 0·109 metre, or $4\frac{5}{16}$ inches.

The best way to lay out a 12-metre or 13-yard wide road is to take the centre, measuring from inside the kerbs, which are presumed to be on same level. Then take a plank, say 6 metres or $19\frac{1}{2}$ feet long, 1 foot in width, and say $1\frac{1}{2}$ inches thick, upon the side of which trace the following diagram :—

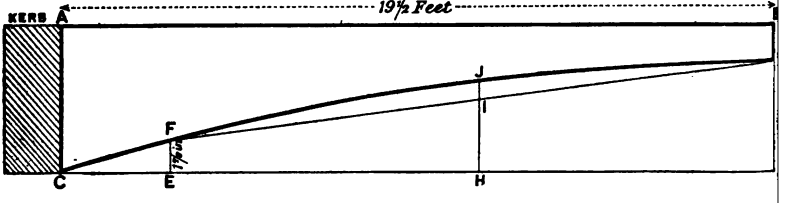


Fig. 19A.—MODE OF SETTING OUT CONTOURING-BOARDS.
N.B.—Vertical scale much exaggerated.

Let A B C D (Fig. 19A) be the configuration, A C the side of the granite kerb, which is 12 inches high, and B D the centre or crown of the road at the highest point, where it is divided thus into two equal parts.

Measure 3 feet 3 inches (1 metre) from the kerb to form the gutter, which requires a greater fall, otherwise in rain storms, and flushing, the water would spread too far over the road; raise a perpendicular 0·048 m. or $1\frac{7}{8}$ inch high, then by joining E and F we have the gutter, which is not steep enough

to cause cart and horses to slide towards the kerb, but sufficiently so to keep the flushing water from spreading and becoming too shallow to carry away the street rubbish, when not too bulky, to the gullies.

At the point D, we trace the perpendicular to get the rise, after deducting the width of gutter, which gives 0·157 m. − 0·048 m. = 0·109 m. or $6\frac{1}{4}$ inches − $1\frac{7}{8}$ inch = $4\frac{3}{8}$ inches is the height of the perpendicular D O. Joining O to F by a horizontal straight line we obtain the subtense of the curve. To obtain the intermediate rise we take the fourth 0·109 m. = $2\frac{3}{16}$ inches at the point H; at half the distance from E to D we raise the perpendicular H I, where it is prolonged to J. By joining the points O J and F C as carefully and regularly as possible, the camber of half the roadway is obtained. One can always get other points by making further similar subdivisions, but in practice it is hardly necessary.

Now, to get the camber edge all that is necessary is to saw the plank according to the curve; C O D then comes away as waste.

In cases where one kerb is higher than the other, the highest point, or watershed, of the roadway is of course no longer in the middle, but, proportionately to the difference between the height of the kerbs, is advanced towards the higher one, but the formula is applied in the same way.

In old cities there are tortuous narrow streets where sometimes the left kerb, sometimes the right

one, is the higher, which causes a good deal of trouble in setting out. (Fig. 20 represents a roadway in which one kerb is 4 inches higher than the other); the highest rise of the camber is no longer

Fig. 20.

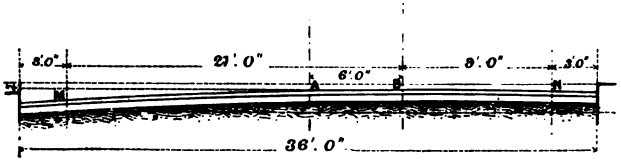


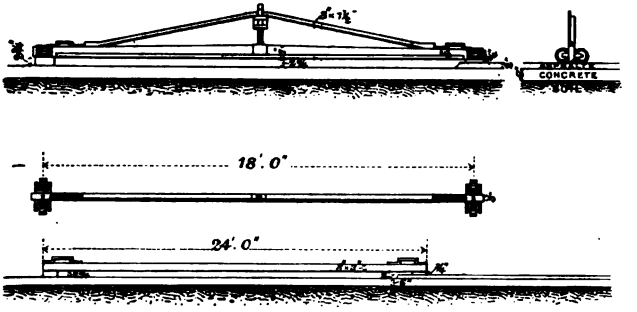
Fig. 21.

the centre A. A longer slope must be given to the side of the inner kerb, so as to correct the inequality. The rise would be at B, from which point the usual fall of 2 in a hundred would be given to the points M and N, and from thence to the kerb a fall of $3\frac{1}{2}$ in a hundred.

For a cross road where the kerbs of each street are unequal, by drawing a straight line from each rise we obtain at their intersection the highest point of the cross road, from which the usual fall of 2 in 100 must be given, so that the water may run off freely.

As cross ways have about double wear and tear, they should have extra thicknesses of concrete and

asphalt. It is generally the engineer or surveyor who gives the points, and the case is one where much practice and experience does as well as science.



Figs. 22, 23, and 24.—IMPLEMENTS USED IN CONTOURING ROADWAYS.

The Soil.—After removing all plaster and soft clay, the soil must be well rammed to camber and well watered to indicate holes; should any holes be found they should be filled in with sound material.

Concrete.—From 1871 to 1878 the author was greatly troubled by being compelled to work with hydraulic lime concretes which were never dry, and formed the opinion that only the best Portland cement concrete could be used with safety for compressed asphalt. Cases of failure in laying stone setts, or wood blocks, can be put

right at the expense of the labour; but a failure in compressed asphalt means a much more serious loss, namely labour and material, which latter must be carted away, cleaned, and ground up for mastic. Relaying annoys the householders, who blame the engineer or architect as well as the contractor.

The best mode of making concrete for asphalt roads is, to say one part of fine-ground Portland cement of best quality add three parts of clean sharp river sand, and four parts of clean pebbles that will go through a ring of 2½ inches diameter, or one part of cement as above to seven parts of clean river ballast, mixed dry, well shovelled together and then just sufficient water added to make it moist (too much water lets the heavy cement fall to the bottom). This mixture is laid out with a flat oblong shovel and afterwards levelled off with a straight-edge and smoothed off with the flat shovel so that the fluid part comes to the top, and thus the application of a floating is avoided; of course, a little mortar must be handy to fill up any cavities after passing the straight edge.

The old plan of spreading a floating over the concrete is injurious, because (1) it does not set at the same time as the concrete, and (2) it gets crushed under the blows of the rammers when the powder is laid.

Some contractors increase the proportion of flint pebbles and sand. One part cement to nine of ballast is used often.

In very hot weather such a concrete will be ready in four days, but in winter seven days is not too much. If it is white on the surface one may be sure it is dry.

Latterly, concretes have been laid during the existence of 20° Fahr. of frost, by using water heated to 85° Fahr., in every gallon of which 1 lb. of carbonate of soda has been dissolved. It is certain that concrete made thus in the depth of winter is dry and apparently sound. The Portland cement mortar sets rapidly, as if it were Roman cement. The action of the soda seems to set back the freezing-point. Whether the process is absolutely safe, only experience can decide.

Time of Laying Asphalt.—In Europe the best time is between the months of May and October, but work often gets done much later, provided there be no frost and snow or continuous wet.

Hot Asphalt Powder.—The powder should be heated from 275° to 280° Fahr., not only to soften its contained bitumen, but also to evaporate the natural moisture contained in the crude rock or powder, which may amount to from 1 to 1½ per cent. of the weight.

Great care must be taken to rake out all burnt or charred lumps, which are inert matter.

While the powder is in the carts it must be well covered with tarpaulins of asbestos, or other cloth, and after being transferred to the wheel-barrows for spreading should be covered with cocoanut

sacking, as soon as spread it should be rammed with the hot rammers; the less heat lost by the powder before ramming or tamping the better. No foreign bodies should ever be left in the powder or concrete.

The powder along the kerbs must be rammed with a special oblong rammer, which is also used for making joints, and a 12-foot wooden straight-edge should be pressed close home to prove that a level surface has been obtained, so that no hollows for puddles can remain. Any bumps must be at once rammed down while the material is still hot.

When the whole surface just rammed is level it must be smoothed with the hot smoothing-irons so as to glaze it and leave no rough face to hold water, then a little fine Roman cement may be sprinkled over and swept in with a soft broom, and the whole rolled with a heavy roller.

If the job can be left for three days so much the better, the atoms will cohere and take their permanent set, but in cities it is difficult to get more than 24 hours, during which time, if the weather be hot, the new road may be rolled with two-wheel carts or trumbrels, first empty, then gradually loaded up; this will consolidate the asphalt and prevent wheel-marks when the street is thrown open to traffic, but in cool or wet weather the cart rolling is not necessary.

The following is the composition of a gang for the laying, say of 500 square yards in a day of ten hours.

2 men (first and second foreman) to rake out the powder when dropped from the barrows, and spread it in a layer of equal density.
2 men to make the joints along the kerbs or drain openings, fire plugs, &c.
12 rammers.
8 smoothers or ironers.
2 men to roll the heavy hand roller.
4 men to roll the wheelbarrows of powder from the horse carts to the site.

Supposing that a 2-inch layer of compressed asphalt be ordered, it is well to trace with a chalked string two chalk lines along the kerb, the upper one for the loose powder, the lower one for the layer after full compression. Some asphalt powders are denser than others, so it is well to get the weight of say 24 lbs. to the square foot.

The plate (see p. 46) shows a square 100,000 square feet in extent, in which can be observed the operation of concrete-making and powder-laying.

If the proper weight per square foot be given, the roadway will roll down level and to a uniform thickness of two inches under traffic.

Footpaths or Sidewalks of Compressed Asphalt are often laid instead of gritted mastic. The light colour is agreeable to the eye and harmonizes with stone buildings; no surface can be nicer or less fatiguing to walk on.

Gritted Mastic Footpaths or Sidewalks.—A slope of 1 in 50 from threshold to kerb is about what is

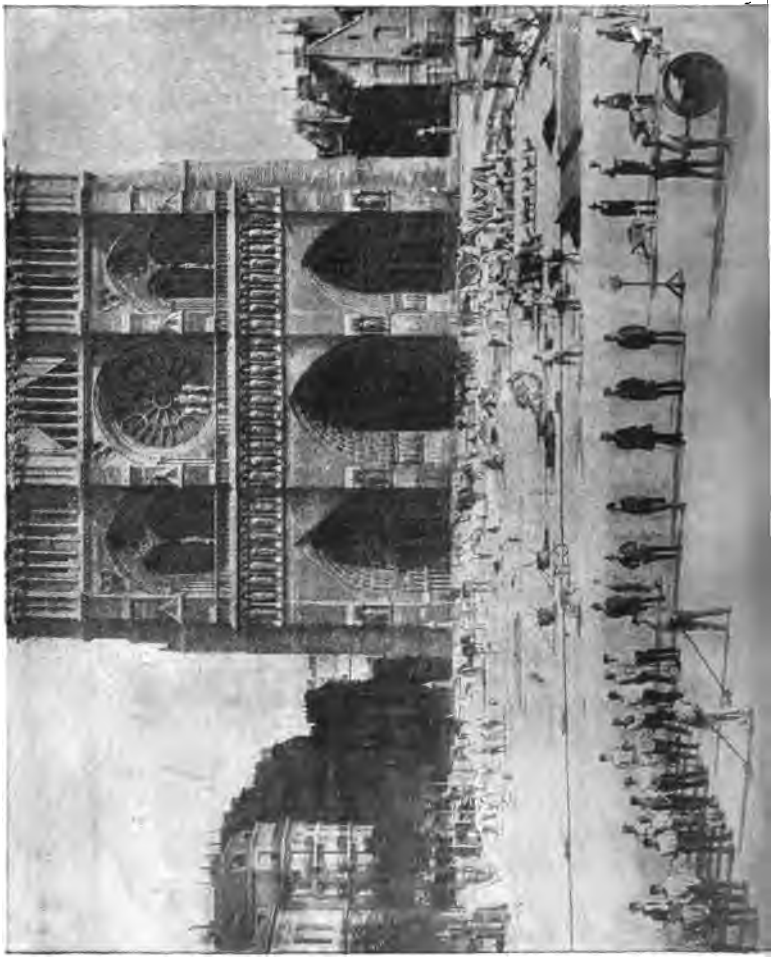


Fig. 25.—ASPHALT OF THE SQUARE IN FRONT OF NOTRE DAME, PARIS—100,000 SQUARE FEET, EXECUTED BY THE COMPAGNIE GÉNÉRALE DES ASPHALTES DE FRANCE. CONCRETE BEING LAID SIMULTANEOUSLY OPPOSITE THE WEST FRONT OF THE CATHEDRAL.

necessary to let the water run off, and a fillet of pure mastic should be laid alongside the thresholds where there is any danger of infiltration, paid for extra.

A 4-inch depth of Portland cement concrete and layer of mastic is sufficient, except for courtyard

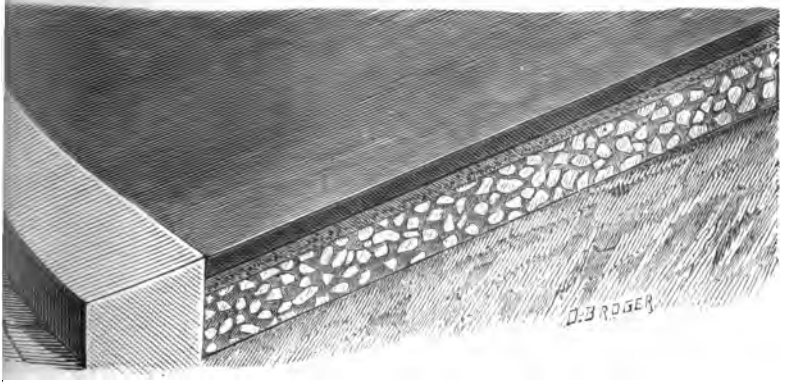
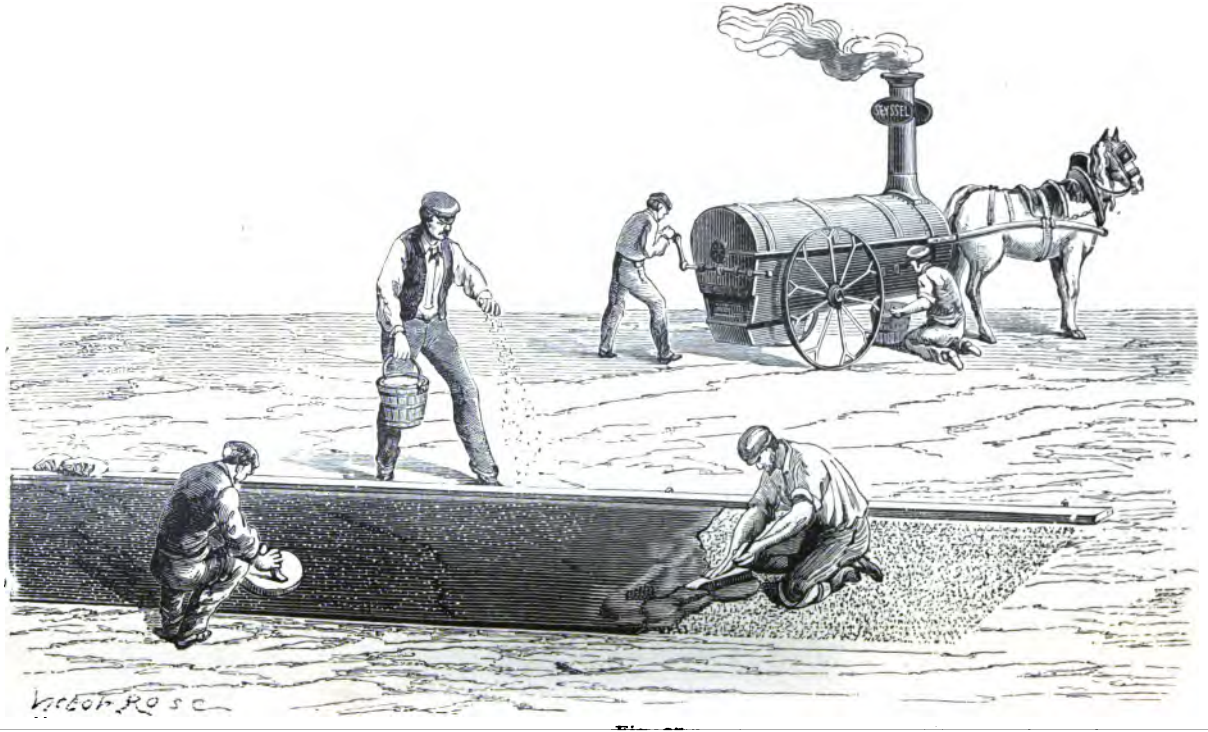


Fig. 26.

entrances, where 6-inch concrete and 2-inch layer of mastic is necessary, the latter in two layers, first smooth, second chequered or cross-cut to afford a foothold to horses.

As before mentioned, in case of repairs, gas trenches, &c., the old materials can be used over again.

Twenty minutes after laying, the surface can be walked over; it is agreeable to the foot, not hard


VICTOR ROSC

nor slippery like cement or granite flags, which in dry weather are slippery, even dangerous.

These famed asphalt promenades are like an impermeable carpet, only never dusty nor dirty if regularly washed down and squeegeed.

The broad Paris Boulevards would lose half

Fig. 28.—PORTABLE FURNACE AND BOILER FOR TRANSPORTING HOT MASTIC.

their charm were they laid in any other material than asphalt; it is the cheapest and the best non-absorbent, smooth and safe.

In hot climates, where frost is not dreaded, more than the usual proportion of 40 per cent. grit may be added to the mastic paste; the gritted mixture

REESE LIBRARY OF THE UNIVERSITY OF CALIFORNIA

should be run hot, pressed, and rubbed in with slate powder or fine sand.

In the large European towns—London, Paris, Brussels, &c.—the gritted mastic is cooked in

Fig. 29.—ASPHALT MASTIC KETTLE WITH ACCESSORIES. MASTIC CAKES BEHIND.

boilers holding 5 tons, driven by steam-power, and the hot material sent out in heated portable boilers (Fig. 28) holding above 1 ton.

This saves blocking the street, and the old materials are carted away by the same vehicle, which has a box for the purpose.

Asphalt kettles are used for work inaccessible to portable boilers.

When used on the public roads, they are put on a layer of sand to prevent damage to the road from the heat and cinders.

A cake of Seyssel mastic, weighing say 56 lbs., will lay about 11 square feet of surface, $\frac{9}{16}$ inch thick, when the grit and bitumen has been added.

First, the kettle being heated, and the cake broken into small pieces by blows from a small sledge hammer, about one-half of the bitumen to be used, say from 5 to 6 per cent. of the weight of the pure mastic, is put in, then when the paste is made by the addition of the pieces of mastic to the bitumen, the dry grit and half the remainder of the bitumen is added (one-fourth of the whole), the rest being kept till the end of the mixing.

The grit is laid on the top of the mastic, and allowed to sink in, and must afterwards be kept constantly stirred. A regular heat must be kept up, not less than 280° Fahr. nor more than 360° Fahr.

Wood or coal or even coke may be used as fuel, and the kettles kept clean by a chisel and hammer. The bottoms are movable, as they wear out soon. In spreading the mastic, there must be no steam bubbles, which arise from wet concrete.

Fine sand dries a wet concrete, and during wet weather, if spreading is compulsory, the mastic should not be too hot.

There must be no hollows where water can lodge.

To get the thickness an iron rule may be used, which as it lies on a rough surface should be a little less thick than the layer to be spread.

Inexperienced asphalters sometimes manage to make the surface-water run in the wrong direction, for instance into a house instead of from it.

It must never be forgotten that we are dealing with an impermeable material.

Mastic is ready to lay when it does not stick to the wooden spatula used for spreading, or by the workman's test, when it instantly evaporates spittle.

For Coatings of Masonry.—Mastic should be used pure, and laid in two layers, each about $\frac{3}{8}$ inch thick, taking care to cover the first joints—i. e. that the joints of the two layers may not be directly superposed.

A recess cut in the masonry and filled with mastic is an extra precaution.

For Casemates.—Military engineers will sometimes have a brass rose and drain-pipe inserted in the mastic where several seams meet, so that the water may be carried off. The rose is surrounded with rubble to keep the dirt off. Otherwise the water remains underneath the bomb-shell proof earth covering till absorbed by same.

When a *flat roof* is asphalted, as is so often the case in countries where no snow falls, and is used

as a belvedere or a drying ground, it is well to lay two layers of mastic—the first pure, the second gritted.

The palace of the Trocadero at Paris was laid thus in 1877, and forms an excellent promenade for the public.

Fig. 30.

For Siloes (Figs. 31, 32).—The application here is the reverse of a casemate, and where green fodder is earthed for winter use or grain stored. No moisture from the surrounding earth nor any vermin can get in.

Vertical Applications are made in pure asphalt mastic to keep out rising surface-water and dampness generally from walls; the material is smeared on and rubbed in as though it were plaster, and with

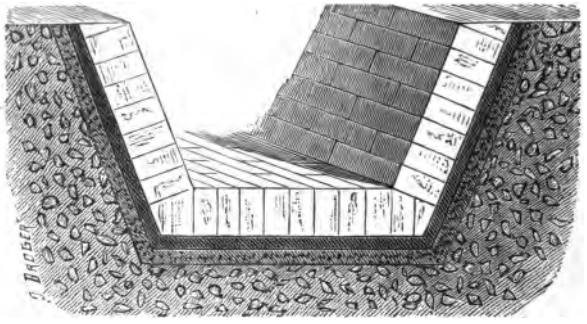


Fig. 31.

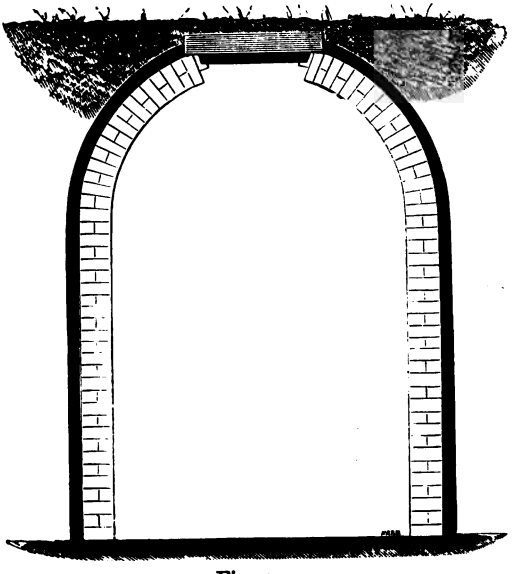


Fig. 32.

plasterer's tools. The wall must not be damp at the time of the application, and it is well to dash some hot liquid bitumen against the wall surface. Two men are required, one to spread and the other to briskly rub in.

Such work is worth nearly double the price of horizontal spreading.

It must always be borne in mind that asphalt has not much power of resistance of its own—it must be supported by a wall built up progressively with the vertical application.

Electricity.—Now that underground wires are so much used, it has been found difficult to obtain a good conduit; cement-concrete cracks and lets in water, iron causes the current to reverse; if the wires are placed naked in the earth there is too much leakage.

The author submits a plan with a drip-groove at each end of the lid (Fig. 13, *ante*, p. 18), which will be watertight and not subject to crack.

From the wires that convey the fluid for lighting purposes at the Paris Opera House (1890), there was 30 per cent. leakage, owing to the condensed water from the engine getting into the covered conduits and rotting the hempen and gutta-percha coating off the wires.

As there was no time for making proper repairs, the author filled up the conduit with hot gritted mastic, drowning the wires. This was a rough and ready remedy, but absolutely efficacious.

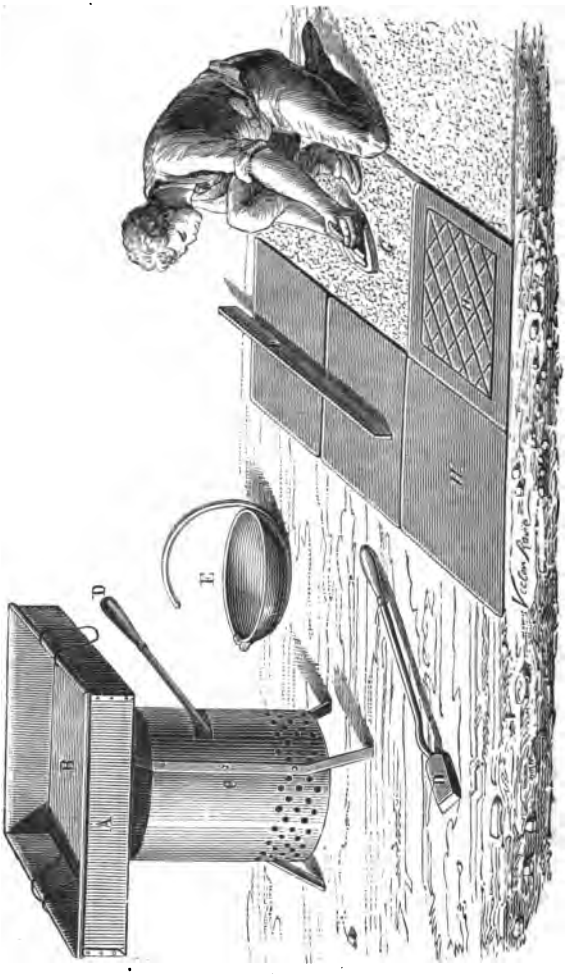


Fig. 33.

Asphalt Flags and Slabs (Fig. 33).

A is a wrought-iron tank containing hot water.

B is a wooden tray on which the asphalt slab is laid for immersion.

C is a stove.

D, D, jointing irons with sharp edge for removing overflow.

E is a ladle for melting the special jointing mastic—it fits on the stove.

F is a wooden rule for proving level surface.

H, I, are slabs, smooth and chequered.

The flags can be sent by railway any distance, and any intelligentlabourer can lay them in towns, stables, out-houses, schools, &c.

PART IV.

GENERAL OBSERVATIONS.

Width of Tires—Heavy Goods Traffic.—There is a proportion between the width of the tires of four-wheeled vehicles and the weight they carry: thus—

Weight carried on four wheels.	Width of Tire.
2 tons	2 inches to 2½ inches.
2½ ,, to 4 tons	2½ ,, to 4 ,,
5 ,, ...	4 ,, to 6 ,,
7½ ,, ...	6 ,,

The diameters of wheels of course vary according to class of goods carried and width of streets.

If such rules were carried out, roads would last longer, but to avoid friction some carters and van-drivers use narrow, rounded tires, which cut like a knife, particularly if the gauge of the fore wheels be the same as the hind ones.

When a powerful lever brake is applied, locking the two hind wheels and causing a heavy vehicle to slide along in varying directions for a distance, say, of half a dozen yards, the road suffers; the trace left by the wheel is hot.

Spreading Salt on Roads in Snowy Weather.—

This is a deplorable practice, snow and salt make a freezing mixture some 28° Fahr. lower in temperature than the air.

This mixture runs down into cracks and joints, and causes disturbance by the expansion of any wet substance with which it may come in contact during the congelation of the other.

It does great harm to shoe leather, and chills the life out of many an unsuspecting wayfarer.

The suffering to dogs who may wade in the mixture is pitiable.

The medical profession have declared against it. It certainly melts the snow on tram-rails. It deprives frozen-out workmen of the job of clearing away snow—a valuable resource for them.

Kerbs should be laid on a concrete foundation and be 12 inches wide and of a proportional depth. Grey granite is the most sightly material, but it requires facing with wrought iron at corners of streets where there is heavy traffic.

Where water lies on the concrete near the kerbs, the author has inserted small iron drain pipes ¼ inch in diameter. A film of water in a crack will act like a wedge under heavy traffic.

Speed of Street Traffic.—From the experience of horse dealers, the pace of draught horses has increased above 25 per cent. since 1872, which of course means more bumping and consequently more wear and tear.

Tramcar Rails increase the cost of maintenance of roads, by concentrating the traffic on either side and augmenting the number of joints.

Tramway companies in Paris have to pay all repairs within 20 inches distance of each rail or double rail.

In towns the track should always have an overlapping foundation of 20 inches thick Portland cement concrete, on which the chairs should be laid direct.

Longitudinal sleepers on ballast are a mistake in towns.

Contracts for the Maintenance of Asphalt Roads and Sidewalks require to be made on a fair basis, to avoid law-suits, oppression, fraud and bankruptcy.

To take an example, a householder buys a carpet. He of course also pays for laying it down, keeping it clean, beating it, repairing the holes which will appear in course of time, and finally when worn out he buys and pays for another one, getting for the old one what he can. A municipality must do the same for its roads and footpaths, or sidewalks.

Conversion of Old Road Surfaces into Compressed Asphalt.—Supposing a roadway in old stone setts or cobbles, in macadam or wood, is to be converted into a roadway of compressed asphalt. The first thing is to be sure that the drain is made; then to

put the gas pipes, electric wires, &c., under the footpaths,* level up the kerbs and put them on a Portland cement foundation, cart away the old materials at the expense of the parish, make the communication with the water-closets and surface water pipes with the main drain at the expense of the householders; then relay the footpath or sidewalk, and after that, if there be any trouble in the roadway, it should be well rammed, watered, and an extra thickness of concrete laid to prevent settlements, which will often occur after three years or more; after that the contractor levels the road, lays the concrete under the superintendence of the authorities, and in due time lays the asphalt as before stated.

The job must be stoutly barricaded and the public kept off, to avoid accidents and let the work be expedited. There must be a watchman at night to keep the lamps alight and prevent accidents.

Guarantee.—In Paris a road laid as above in August is taken over provisionally on the following 1st May, then, if in good order, it is passed, but left in the contractor's hands at his risk till the 31st December following; after which, if still in good order, it is taken over definitively by the municipality and parish as their own property, and all repairs are at their charge.

* Unless there be subways, a most valuable adjunct to a road, of which Colonel Haywood, the City of London Engineer, has made many.

Payment.—Sums on account are paid upon the engineer's certificate as the work progresses, but one-tenth is always retained till the definitive reception has taken place.

Maintenance is of two kinds, 1st that of gas and water and electricity trenches, changes of levels, widenings, &c., which is paid according to the schedule of prices, with a premium for surfaces from 1 to 100 yards, also for settlements; trenches should always be measured from the bottom not the top, the contractor removes the earth and old materials at schedule prices; (2) Maintenance for wear and tear.

Now according to the simile of the householder's carpet, the municipality or parish would keep paying the necessary repairs as caused by the traffic or "wheel wear," until at a given time it would have to relay the entire asphalt surface and level up the concrete bed, if there had been many trenches, at its own expense. Of course the old asphalt has a certain value, but it has to be carted to the contractor's yard, stored, cleansed, ground up, all of which means expense to the contractor, who has also to wait the opportunity of using it, so that it is often given for the cartage as its storage on expensive land soon eats up its value.

But, instead of paying for its repairs by surface as required, the town of Paris resolved to pay a fixed sum per square measure of surface, a sum based upon its expenses during three years, leaving

all the rest to the contractor, who is at the beck and call of its engineers, for all necessary repairs, whatever they may be in extent, which is an easy method in a large city, and causes a large saving in figures and red tape.

This sum is 2 francs per square meter, or say 1*s.* 4*d.* or 32 cents per square yard for compressed asphalt roadways, and 35 centimes per square meter, say 3*d.* or 6 cents per square yard for gritted asphalt footpaths or sidewalks.

The contract is made for ten years, and at the end of that time the surface must be in good order, but of the thickness no note is taken.

It may happen under such a contract that the contractor may lose money upon the maintenance of certain streets, but others will give him a profit and so compensate.

Of course under such a system the contractor is not supposed to lose, still he often does, owing to prolonged bad weather, unusual traffic, bad concrete, &c., so that it is usual to give him all new work up to 3000*l.* or 15,000 dollars, without rebate.

The system of paying a fixed price for repairs of whatever extent is a risk for the contractors, and if undue severity is exercised by the authorities may lead to his ruin, but it is never the interest of a municipality to punish an honourable contractor. Still, coercive means are reserved for dishonourable contractors, and caution money is required for large contracts which may rise to 12,000*l.* or 60,000 dollars, bearing 3 per cent. interest.

The city of Berlin requires a 5 years' guarantee, and pays maintenance for 15 years afterwards. Caution money is required, for which 4 per cent. is paid; but the traffic of Berlin is easy compared to that of London, and above all to that of Paris, which is the heaviest known.

The city of New York requires a 5 years' guarantee for some work and a 15 years' guarantee for other, maintenance of which must be included in the bid for the whole time.

New York does not vote annual sums for maintenance as other towns do, and instead of caution money requires bondsmen; two-thirds of the money is paid down and the other third paid in small sums until the guarantee is expired.

The system is not so good as that of Paris or of London (which latter is nearly the same as that of Paris), or of Berlin, because contractors cannot calculate how much the wear and tear of a big town increases. It is certain that many streets at the end of ten years will have cost as much to repair as was paid for the asphalt, including concrete, when laid.

One well-known contractor in New York has preferred (1892) to abandon say 142,000 dollars owing to him by the municipality rather than continue repairs, which at the end of 15 years will have cost three times that sum or more.

The only one who can gain by this is the outside contractor called in to do repairs as long as the funds last.

The city of London requires two years' guarantee for new work, after which it pays a fixed sum for maintenance per square yard during 15 years, according to the traffic of the street.

Thus, Cheapside, London—2¼-inch compressed asphalt on 9-inch Portland cement concrete—was paid 18*s.* or 4·32 dollars per square yard, and, the guarantee time expired, 1*s.* 6*d.* or 36 cents maintenance per square yard during 15 years.*

The author has been informed that Cheapside, which was and is a marvel of endurance, was a loss to the contractors in the latter years before it was relaid.

During the whole of the 17 years this important thoroughfare was never stopped for repairs, i.e. from 1870 to the end of 1887, although when the old granite setts were used, it had to be relaid every 4 years.

It was relaid at the rate of 800 square yards a day with comparatively little inconvenience to the public.

Low Prices.—It is not well for a contractor's prices to be cut too low; experience has shown that very low prices mean one of two things, either ruin to the contractor, which is a public misfortune of frequent

* See the report of Colonel Haywood, Engineer and Surveyor to the City of London, Engineer's Office, Guildhall, London. It was this distinguished engineer who introduced compressed asphalt into London, in 1869—a boon indeed for those old narrow streets and alleys.

occurrence, or else cheating, i. e. substitution of second class materials, insufficient thicknesses, &c., when the town suffers — sometimes found out too late. Fraud is always more active than supervision.

Poor human nature must not be tempted too far. High duties produce smuggling; excessive income tax leads to false returns of income; very low prices in contracting lead to cheating.

Municipalities should encourage honourable contractors who do good work, by only allowing those contractors to compete for important jobs who have capital, plant, good materials, and an unblemished reputation.

A needy, incompetent and dishonest contractor does infinite harm to those who trust him, whilst doing no good to himself.

Imitations of Natural Asphalt.—These are of two classes, the first and foremost is a material made of white limestone sand, and Trinidad or other mineral pitch.

Trinidad pitch always contains 25 per cent. of clay, whereas the bitumen or pitch naturally contained in asphalt rock is chemically pure.

Bitumen can be added to natural asphalt, because nature has shown the way.

If you have an oil stain in a piece of cloth, and pour fresh oil on, it will soak into the part already stained much more readily than into the part still intact.

The fact is, that it is about as easy to imitate natural asphalt as to imitate granite or coals.

There is no chemist like nature. However, in the United States, a man of great natural gifts and extraordinary energy, Mr. Barber, has founded a powerful company for making roadways of the Trinidad pitch compound above alluded to.

Of this artificial compound, more than 5,000,000 square yards have been laid in various towns of the great continent. It resists well enough where there is little traffic, but tried in Paris, Berlin, and the heavy traffic streets of New York, like Wall Street and Chambers Street, it scales away at the surface and breaks up rapidly.

Mr. Barber is preparing the way for a better pavement, i.e. compressed natural asphalt. In America, as elsewhere, the best article always comes to the front in the end, and the best is always the cheapest in the long run.

Some engineers will argue that it is well to use a cheap though inferior material for streets with little traffic.

The author, however, would venture to assert that it is always advantageous to use the best material, and arrive at lower prices by modifying the thicknesses of the concrete and asphalt layer.

Yet in Berlin the town engineers have always laid 8-inch Portland cement concrete, and 2-inch asphalt, and probably in the end their plan is most economic, as streets with small traffic often become

streets with heavy traffic in the course of 20 years, say.

In London, during the year 1871, many imitation asphalts were tried—such anomalies as "iron asphalt," "india-rubber asphalt," "granite asphalt," "slate asphalt." They have all disappeared—only the real article remains.

In Paris, about 1880, a plan of sprinkling asphalt powder with collodion to soften the bitumen was tried, instead of heating, the object being to allow of repairs being done in wet weather without vaporising the water, as the hot asphalt powder does, thus causing nodulous formation in the compressed layer.

The inventor had used collodion for moistening gunpowder, and of so obtaining a greater compression in the cartridge, but he forgot that heating was necessary, not only for softening the bitumen, but also for chasing away the 1¼ per cent. of water contained in the natural rock, and which, if left in, would cause breaking up in frosty weather.

This so-called cold asphalt has long disappeared from the streets of Paris.

The second imitation of natural asphalt is made by using shale-oil, or petroleum-still bottoms, instead of Trinidad, and mixing sand with limestone. This compound goes soft in summer, and has little power of resistance.

The third and most redoubtable imitation is that in which gas-tar is used instead of bitumen, on

account of its cheapness. Mastic made with gas tar, is soft in summer and brittle in winter.

When used under its own name of gas-tar mastic, nothing can be said; unfortunately, having nearly the same colour as natural asphalt mastic, it gets palmed off as the real article, although the appearance, the fracture-colour and smell are not the same. That does harm, as the engineer and architect, once deceived by an unprincipled contractor, may afterwards taboo real asphalt, and prefer to it cement, tiles, bricks, &c.

Gas-tar mastic can be detected otherwise than by the result it gives—1st, by its acrid odour; 2nd, its metallic sound when cold, its fluidity when hot.

Gas-tar contains the aniline dyes, which are not found in mineral pitch.

It would be better for gas-tar to be used for its chemical derivatives, or for agglutinating coal-dust (compressed fuel), than for making imitation asphalt, which is not trustworthy, even when free from atmospheric influences.

Traffic of Paris.—Asphalt streets laid by the Compagnie Générale des Asphaltes de France, the originators of the system:—

Rue de Rivoli	{number of vehicles passing in 24 hours}	42,035
Rue Croix des Petits Champs	do.	20,480
Rue St. Honoré	do.	19,672
Rue Auber	do.	14,082
Avenue de la Grande Armée ..	do.	8,149

Whereas the highest traffic in London for asphalted streets is—

King William Street	{number of vehicles passing in 24 hours}	26,793
Gracechurch Street	do.	15,585
Queen Victoria Street	do.	16,531
Cheapside	do.	15,206
Aldgate	do.	14,200
Holborn Viaduct	do.	12,158
Newgate Street	do.	13,128
Moorgate Street	do.	11,398
Cornhill	do.	9,572

These figures are taken from a report by M. Barabant, late chief engineer of the city of Paris, now general manager of the Eastern Railway Company of France.*

Macadam.—The wear and tear of macadamised roads in Paris, the extent of which is, say 2,167,800 square yards, or $\frac{22}{100}$ of the entire surface of Paris roadways,† absorbs daily 390 cubic yards of materials or a train-load of thirty-six waggons.‡

Where does the detritus of this immense daily cube of broken stone go? Into the respiratory organs of the Parisians, their hair, clothes, houses; into the street gutters, thence to the drains, and

* 'Note sur les questions de viabilité, par M. Barabant, Ingénieur en chef de la voie publique.' Chaix, 29 Rue Bergère, Paris.

† 'Note sur l'entretien des voies publiques de Paris, par M. Allard.' 11 Rue Cadet, Paris.

‡ 'Variations de la circulation dans les rues de Paris de 1872 à 1887, par M. André, Ingénieur en chef.' 17 Rue Cadet, Paris.

thence again to the river Seine, to form therein banks of silt and mud, which must be dredged away or navigation would eventually be stopped. No wonder that its suppression is desired. Its cost is terrible; the maintenance of a crowded thoroughfare being half the cost of laying a new asphalt road, including the concrete foundation.

Work done by Parishes and Municipalities without the Intermediary of Contractors.—It may be laid down, that work done by the parish or municipality is in the end always dearer than that done by honourable contractors, although by the way of stating the case, it may appear at first sight cheaper. A parish has the inherent right to do its own work, be its own contractor in fact, only it certainly should not compete with the contractor for public and private work.

In Paris the city lays its own wood, rolls its own macadam, does its own paving repairs, though not those for kerbs, does its street-cleaning, but not the carting away of dung, detritus, rubbish, and snow.

The parish or municipality pays no rates and taxes, buys its raw material as cheap as the contractor, uses its engineers and staff engaged for control without extra payment, but it is hampered by the system of accounts, has to pay its staff at the depots, the rent of same, and interest on cost of machinery plus repairs, whether work is going on or not, and in case of failure has no one to hold

responsible. The result is invariable—work is slow, labour dear and inefficient.

It is a well known fact in Paris that the contractor gets three times more work out of his men than a parish; he has picked men and pays them proportionately. Then supposing wood pavement laid in Paris by the town staff to cost apparently 20 per cent. less than the contractor's price; the maintenance in any case will cost three and a half times as much.

It is, however, probable that if instead of making an estimate of the first cost, the actual figures were taken—rent, taxes, loss of time owing to lack of materials (a frequent case), and a fair apportionment of engineer's salary and that of the staff, the cost would be 20 per cent. more.

It seems only fair that if a parish exacts poor-rates and taxes from contractors, it should not deprive them of the means of earning something.

Cost of Work in Paris.—Paris being the town in which the asphalt trade took its rise, the author thinks it well to give the prices paid there, of course premising that in other countries there is additional carriage from the mines, and sometimes custom duties, as in Amercia, Canada, and Austria, on the manufactured material, but not the raw rock.

Wage of an asphalter,	per hour	.. ..	$7\frac{1}{2}d.$ or 15 cents.
,, help	,,	.. ..	$5\frac{1}{2}d.$,, 11 ,,

	Per square yard.
Portland cement concrete, 6 in. thick ..	3*s.* 8*d.* or 88 cents.
,, ,, 8 ,, ..	4*s.* 8*d.* ,, 1·12 dollars
Liquid asphalt mastic gritted, $\frac{3}{4}$ in. thick	4*s.* 2*d.* ,, 1·00 ,,
,, pure, no grit, $\frac{9}{16}$,,	4*s.* 2*d.* ,, 1·00 ,,
,, when laid vertically ..	5*s.* 6*d.* ,, 1·32 ,,
Natural compressed asphalt, 2 in. thick	9*s.* 2*d.* ,, 2·20 ,,
For jobs up to 10 yards on surface ..	20 per cent. cubic.
,, of 10 to 20 yards on surface	10 ,,

Fillets extra, canvass or paper when spreading on wood, extra.
Grey granite kerbs, 12 inches by 12 inches, on concrete and jointed complete, 13*s.* 2*d.* or 3·64 dollars the running yard.

Old gritted mastic, old pure mastic, old compressed, are taken back by special arrangements.

Chicago World's Fair, 1893.—Specimens of all the natural substances described in foregoing pages will be found in Class 12, Mines; and the author will be happy to receive any correction or notice in view of a second edition later on.

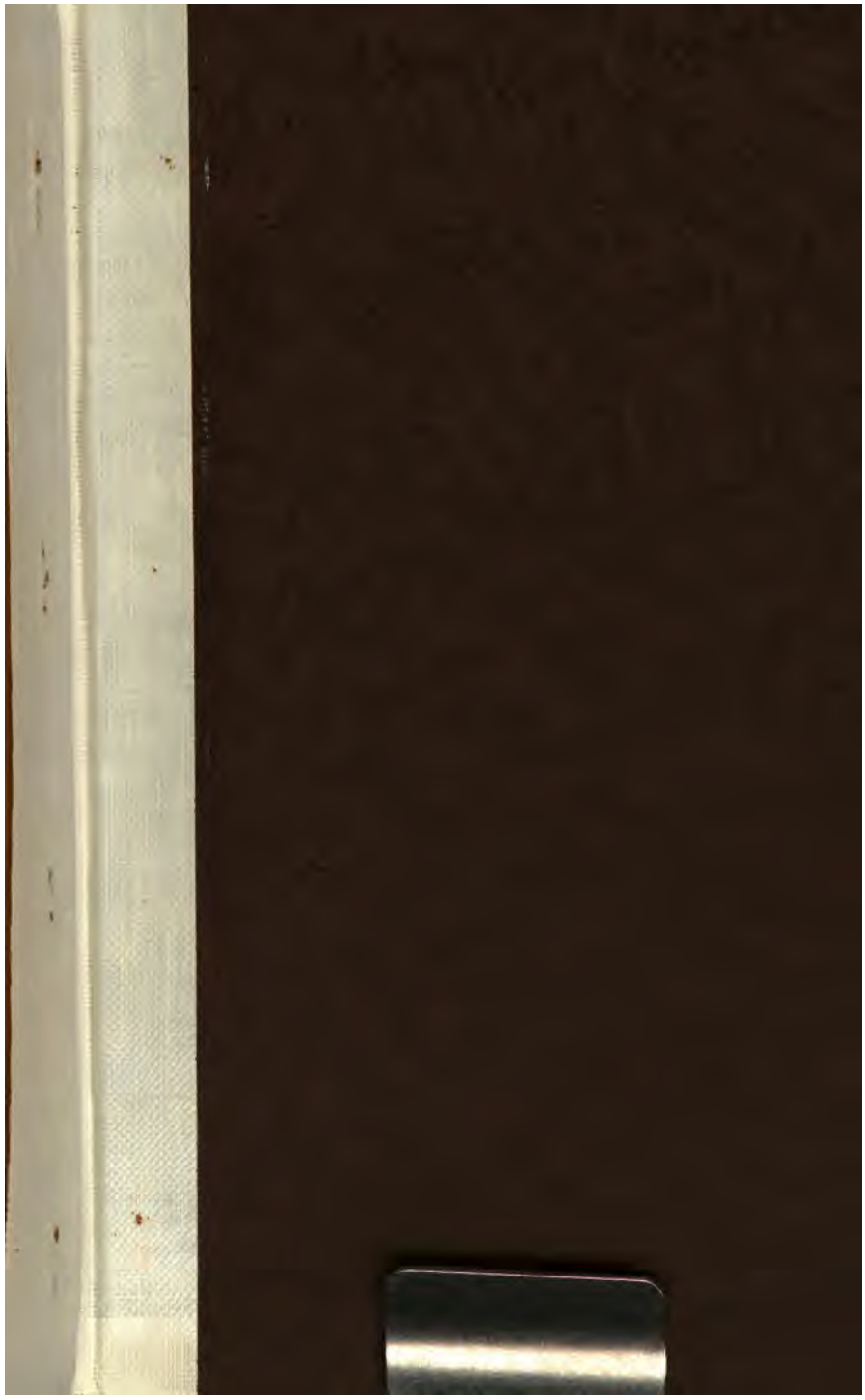
REESE LIBRARY OF THE UNIVERSITY OF CALIFORNIA.

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, LIMITED, STAMFORD STREET AND CHARING CROSS.

THIS BOOK IS DUE ON THE LAST DATE
STAMPED BELOW

AN INITIAL FINE OF 25 CENTS
WILL BE ASSESSED FOR FAILURE TO RETURN THIS BOOK ON THE DATE DUE. THE PENALTY WILL INCREASE TO 50 CENTS ON THE FOURTH DAY AND TO $1.00 ON THE SEVENTH DAY OVERDUE.

JAN 23 1941

14 Mar '50

LD 21-100m-7,'39 (402s